

## **Device For Simulating Some Aspects Of Cigarette Use**

### **1. Field of the Invention**

**The present invention relates generally to the field of smoking simulators, and more particularly to the field of devices which demonstrate to teenagers the loss of control over their lives caused by the habit of smoking cigarettes.**

### **2. Description of Related Technology**

**Cigarette smoking is an addictive habit which is extremely difficult to break. The harm to a person's health caused by smoking is well documented. Furthermore, the habit is costly to support even if the user is not a heavy smoker. Numerous devices have been developed to help smokers quit, such as United States Patent No. 3,999,412, issued to Boroski et al. The Boroski et al. device is a cigarette case which counts and rations the number of cigarettes dispensed to the user.**

**Various smoking elimination systems utilize a timer which establishes a basic timing period during which a cigarette case or lighter is locked. These patents include U.S Patent No. 3,744,953, issued to Herr, U.S. Patent No. 2,681,560, issued to Shuttleworth et al. and U.S. Patent No. 2,643,527, issued to Harris. When the basic timing period is over, the cigarette lighter or box may be opened to permit a single use of a cigarette. Sometimes the timing period is manually adjustable and generally the timer must be manually reset each time a cigarette is removed from the case or a cigarette lighting operation takes place. In such a smoking elimination system, each time the user desires to smoke, she must try to operate the cigarette lighter or open the cigarette case to determine whether or not she can smoke. A related device is disclosed in U.S. Patent No. 3,424,123, issued to Giffard, in which the lock is eliminated and a bell signals the user that the basic timing period has expired.**

Other more interactive programmable devices have been developed to assist, monitor, control or record various types of human behavior. U.S. Patent No.4,100,401, issued to Tutt et al. discloses a device that permits a user to input data representing caloric intake as well as expected caloric expenditure rates. The device then displays the instantaneous net balance of unconsumed calories. The Tutt et al. device does not generate any personalized program for behavior modification or any personalized programmed schedule of future event times. U.S. Patent No. 4,144,568, issued to Hiller et al. discloses a device which records various personalized data and provides related output data to the user. While the output data may be of interest to the user and might conceivably affect the user's future activities, the Hiller et al. device does not actually stimulate human behavior modification in any meaningful sense.

U.S. Patent No. 4,281,389, issued to Smith describes a device which is programmed to provide personalized metronome like audible signals designed to pace every other stride of a long distance runner. The necessary data may be manually input prior to the run, or the runner may manipulate manually accessible controls and modify the programming so as to conform with her actual stride frequency during a given run. Thereafter, the device is capable of providing a modified programmed stride rate so as to signal the stride rate required to achieve a desired run time.

U.S. Patent No. 4,360,125, issued to Martindale et al. shows a medicine dispenser which signals the user each time a medication event is supposed to occur and also records the time at which each medication access by the user actually occurs. The device only provides a health care worker with such a factual record and no attempt is made to create any modified program schedule for the future. U.S. Patent No. 4,428,050, issued to Pellegrini et al. discloses a device which accepts personalized data relating to skin tanning parameters and then provides the user

5 with a program which should be followed so as to achieve a desired degree of tanning. There is no baseline learning phase, nor is the device directed toward modification of habitual human behavior associated with a sequence of events.

U.S. Patent No. 4,853,854, issued to Behar et al., discloses a behavior  
10 modification device to help a user quit smoking. The device is a small pocket sized device that is controlled by a microprocessor programmed in read only memory with a specific control program. When a user activates the device by means of an external switch, the device begins a baseline establishment phase of the behavior modification process. Each time the user performs a habit related event, the user  
15 informs the device through the use of a switch. The device records the event at the time of its occurrence for future processing. The device remains in the baseline phase for a predetermined period of time. When the baseline period ends, the device notifies the user and proceeds to the withdrawal phase of the program. Once the personalized withdrawal phase occurs, the device prompts the user by providing  
20 visual and audio stimuli as to when the user may smoke one cigarette. A visual display also informs the user as to when permission to smoke again will be granted. The user notifies the device that the prescribed event has been committed by activating a switch.

25 Some devices exist which require a user to actually exhale into a handheld unit. An example of such a device is disclosed in U.S. Patent No. 5,291,898, issued to Wolf. The Wolf device is a breath analyzer which contains a tube into which a user exhales, the breath sample being analyzed for its alcohol content.

30 While some of the aforementioned devices deal with smoking and behavior modification, none address the problem of preventing a person from smoking who has never engaged in the habit. Further, none of these devices are actuated in a manner that attempts to accurately simulate the actual act of smoking. For example, none of the prior art devices simulate the spending of money to purchase

5 cigarettes, cause the user to crave a cigarette at inconvenient times due to nicotine addiction or simulate coughing caused by long term cigarette use.

## Summary of the Invention

10 The present invention is a device which demonstrates to prospective smokers, who are most likely teenagers, the loss of control over their lives caused by smoking. The device is preferably a box which has the same dimensions and appearance as a package of cigarettes. The box contains a microprocessor connected to a liquid  
15 crystal display which displays messages to the user, or preferably a voice recognition and synthesis circuit to permit spoken interaction with the device. The device gives orders to the user which simulate the effects of smoking while monitoring the user's responses. The device also presents the user with general information relating to the disadvantages of smoking and emphasizes the control that the habit of smoking can exert on the user's life.

20 The simulator also includes a vibrator and speaker or beeper to prompt the user to read the LCD display. A bellows switch is included to detect the action of the user inhaling or exhaling through a tube to simulate the drawing in of air through a cigarette and the need to catch one's breath after each draw. The tube is  
25 replaceable to permit the use of the simulator by different users. Occasionally the device will cough or the user will be prompted by the device to cough and the act of coughing is detected by a built in microphone.

30 In order to simulate the expense associated with the habit of smoking, a slot can be formed in the side of the simulator box which is sufficiently large to accept a dollar bill or suitable money substitute. A microswitch is placed within the cavity to detect when a dollar bill is actually inserted into the simulator. In a classroom environment, the currency accepting cavity can be opened by a key which is in the possession of the teacher. The times when the student is both permitted to smoke or

5 required to smoke can be programmed into or calculated by the unit, and a  
pushbutton on the outside of the device can toggle through a choice of such time  
periods in, for example, five minute increments.

10 In one preferred embodiment of the device, the smoking simulation program  
which can be experienced by use of the device will last approximately three days.  
The first day simulates the demands of smoking approximately one half of a  
package per day. The second day simulates about one pack per day. The third day  
of the simulation approximates the use of two packs per day. The messages  
displayed by the device, which can include both requests and information, become  
15 increasingly demanding and onerous as the simulation progresses. Ideally, the  
simulator is capable of delivering hundreds of such messages in order to maintain  
the user's interest. When the program is complete, the student has gained a better  
understanding of the expense and inconvenience of smoking. The device is capable  
of storing various parameters related to the student's interaction with the device,  
20 and these parameters can be reviewed by the teacher in order to evaluate the level of  
the student's performance.

### **Brief Description of the Drawings**

25 Figure 1 is a front elevation of a smoking simulator constructed according to  
the principles of the present invention;

Figure 2 is a side elevation of the apparatus depicted in Figure 1;

Figure 3 is a plan view of the apparatus depicted in Figure 1;

Figure 4 is a schematic diagram of a portion of the present invention which  
30 includes a microprocessor and random access memory;

Figure 5 is a flow chart depicting the general operation of the present  
invention;

Figure 6 is a flow chart depicting the powerup and initialization portion of  
the software depicted in Figure 5;

5           **Figure 7 is a flow chart portraying the “Teacher Interrupt” portion of the software referred to in Figure 5;**

**Figure 8 is a flowchart of a portion of the present invention which portrays the RUN subroutine;**

**Figure 9 is a flowchart of a portion of the present invention which portrays**  
10 **the SMOKING NOTIFICATION subroutine;**

**Figure 10 is a schematic diagram of a preamplifier and power supply constructed according to the principles of the present invention;**

**Figure 11 is a flowchart depicting the INFORMATION NOTIFICATION subroutine utilized by the present invention;**

15           **Figure 12 is a side sectional view of one embodiment of a puff receptacle and sensor associated with the present invention;**

**Figure 13 is a perspective view of a second embodiment of a puff receptacle associated with the present invention;**

**Figure 14 is a flowchart depicting the COUGHING INTERRUPT subroutine**  
20 **utilized by the present invention;**

**Figure 15 is a flowchart depicting the STUDENT PUSHBUTTON INTERRUPT subroutine associated with the present invention;**

**Figure 16 is a flowchart depicting the SMOKING ACTION subroutine utilized with the present invention;**

25           **Figure 17 is a flowchart depicting the BUM CIGARETTES subroutine which forms a part of the present invention; and**

**Figure 18 is a flowchart depicting the INFO ACTION subroutine utilized during operation of the present invention.**

## **Detailed Description of the Preferred Embodiments**

### **Nomenclature**

1     Smoking simulation apparatus

5	2	Case
	3	Edge
	4	Hinge
	5	Surface
	6	Lid
10	7	Rear Surface
	8	Receptacle
	9	Speaker
	10	Microphone
	11	Recess
15	12	Switch
	13	Perforations
	14	Front
	15	Display Window
	16	Earphone Jack
20	17	Puffing Device
	18	Side
	19	Microcontroller
	20	Random Access Memory
	21	Data D7 pin 2
25	22	Data D6 pin 3
	23	Data D5 pin 4
	24	Data D4 pin 5
	25	Data D3 pin 6
	26	Data D2 pin 7
30	27	Data D1 pin 8
	30	Data D0 pin 9
	32	Visual Display
	33	Core Ground pin 33
	34	Core Power supply input pin 34

5	35	I/O 1.7 pin 35
	36	I/O 1.6 pin 36
	37	I/O 1.5 pin 37
	38	I/O 1.4 pin 38
	39	I/O 1.3 pin 39
10	40	I/O 1.2 pin 40
	41	I/O 1.1 pin 41
	42	I/O 1.0 pin 42
	43	I/O 0.7 pin 43
	44	I/O 0.6 pin 44
15	45	I/O 0.5 pin 45
	46	I/O 0.4 pin 46
	47	I/O 0.3 pin 47
	48	I/O 0.2 pin 48
	49	I/O 0.1 pin 49
20	50	I/O 0.0 pin 50
	51	Memory Data port D0 pin 13
	52	Memory Data port D1 pin 14
	53	Memory Data port D2 pin 15
	54	Memory Data port D3 pin 17
25	55	Memory Data port D4 pin 18
	56	Memory Data port D5 pin 19
	57	Memory Data port D6 pin 20
	58	Memory Data port D7 pin 21
	59	Data bus
30	60	Address Bus
	61	Address Line A1 pin 26
	62	Address Line A2 pin 25
	63	Address Line A3 pin 24
	64	Address Line A4 pin 23



- 5    **65**    Address Line A6 pin 21
- 66**    Address Line A7 pin 20
- 67**    Address Line A8 pin 17
- 68**    Address Line A9 pin 16
- 69**    Address Line A10 pin 15
- 10   **70**    Address Line A11 pin 14
- 71**    Address Line A12 pin 13
- 72**    Address Line A5 pin 22
- 73**    Address Line A 13 pin 12
- 74**    Address Line A14 pin 11
- 15   **75**    Address Line A15 pin 10
- 76**    Address Line A0 pin 27
- 77**    Power Supply
- 78**    Analog Power Supply
- 79**    Battery
- 20   **80**    Capacitor
- 81**    Diode
- 82**    Air Jets
- 83**    Resistor
- 84**    470 microfarad capacitor
- 25   **85**    Audio Preamplifier
- 86**    Terminal
- 87**    Core Power Supply
- 88**    2.2 ohm resistor
- 89**    Electrolytic Capacitor
- 30   **90**    Input/Output Power Supply
- 91**    Resistor
- 92**    Capacitor
- 93**    Resistor
- 94**    Capacitor

- 5    **95**    Reset Terminal
- 96**    Diode
- 97**    Bandpass Filter
- 98**    Automatic Gain Control Circuit
- 99**    IGAIN0 Terminal
- 10   **100** IGAIN1 Terminal
- 101** 1000 ohm resistor
- 102** 22000 ohm resistor
- 103** 10000 ohm resistor
- 104** First Stage amplifier
- 15   **105** Third Stage amplifier
- 106** 0.22 picofarad capacitor
- 107** 4700 ohm resistor
- 108** 680000 ohm resistor
- 109** 27000 ohm resistor
- 20   **110** 1000 ohm resistor
- 111** 0.22 picofarad capacitor
- 112** Fourth Stage amplifier
- 113** 56000 ohm resistor
- 114** 1000 ohm resistor
- 25   **115** Low Analog Output terminal
- 116** High Analog Output terminal
- 117** Digital Ground Pin18
- 118** Digital Power supply input pin 19
- 119** Digital Ground Pin 52
- 30   **120** Digital Power supply input pin 51
- 121** 0.1 microfarad capacitor
- 122** Digital Ground
- 123** Core Ground input pin 1
- 124** Core Power supply input pin 68



- 5    **157** Input/Output port 0.1 pin 49
- 158** Input/Output port 0.2 pin 48
- 159** Input/Output port 0.3 pin 47
- 160** Microswitch
- 161** Bellows Switch
- 10   **162** Sound Activated Switch
- 163** Pushbutton
- 164** Flow restrictor
- 165** Puffing device
- 166** Mounting Bracket
- 15   **167** Check Valve
- 168** Filter
- 169** Overview Flowchart
- 170** Powerup and Initialize
- 171** Run
- 20   **172** Bootup procedure
- 173** Password request and store
- 174** Sleep mode
- 175** Voice verification
- 176** Time Entry prompt
- 25   **177** Clock Startup
- 178** Teacher Prompt
- 179** Pushbutton
- 180** Teacher Interrupt
- 181** Wakeup from sleep
- 30   **182** Request prompt
- 183** Report Command
- 184** Run Command
- 185** Buy Cigarettes Command
- 186** Packs Per Day Command

5	187	Escalation Rate Command
	188	Metabolic Rate Command
	189	Susceptibility Command
	190	Information Frequency Command
	191	Set Number of Packages
10	192	Initial Smoking Rate
	193	Escalation Rate
	194	Metabolic Rate
	195	Susceptibility
	196	Information Rate
15	197	Return Path
	198	Verification of Password
	199	Brand Selection
	200	Personality
	201	Physiological Parameter Calculations
20	202	Nicotine Craving Level
	203	Smoking Action Module
	204	Internal Timers
	205	Smoking Notification Module
	206	Notification Methods
25	207	Device Scheduler
	208	Information Notification Module
	209	Notification Options
	210	Notification Timer
	211	Coughing Interrupt Module
30	212	Notification Methods
	213	Cough Prompt
	214	Retry Option
	215	Record Success
	216	Record Failure

- 5    **217** Student Command
- 218** Random Number Generator
- 219** Belligerence Path
- 220** Repetition Step
- 221** Cooperation Path
- 10   **222** Borrowing Module
- 223** Information Action Module
- 224** Inventory Inquiry
- 225** None Available Announcement
- 226** Smoking Permitted Announcement
- 15   **227** Continuous Listening Subroutine
- 228** Consumption Rate Calculator
- 229** Return path
- 230** Counter
- 231** Demand
- 20   **232** Message Bank
- 233** Message Generator
- 234** Sound Monitor
- 235** Interrogatory
- 236** Record Failure
- 25   **237** Deathclock monitor
- 238** Recorder
- 239** Cigarette Inventory
- 240** Question
- 241** Failure Path
- 30   **242** Listen
- 243** Recognition
- 244** Playback
- 245** Decrement
- 246** Loop

- 5    **247** Tone Recognition
- 248** Increment
- 249** Question
- 250** Listening Interval
- 251** Correct Answer
- 10   **252** Correct Register
- 253** Incorrect Register
- 254** Dollar Bill Slot

Referring to Figures 1, 2, 3 and 12, a smoking simulation apparatus **1** is shown  
15 which is housed in a case **2** which approximates the rectangular shape and dimensions of  
a package of cigarettes. The case **2** is formed of a plastic or metallic material and houses  
the mechanical and electrical components which comprise the active components of the  
device. Analogously, the embodiment for other drug deterrence purposes might take the  
form of a package of hypodermic needles or other drug-related paraphernalia. The intent  
20 is to provide some sense of connection in the mind of the user between the deterrence  
device and the addiction or habit being deterred.

On the front **5** of the enclosure **2** are grills for the speaker **9** and microphone **10**,  
which are mounted inside. The grill for the microphone consists of two parts. First there  
25 is the central receptacle **8** for the straw portion of the simulated cigarette to fit into. This  
is the also primary opening for the microphone **10** to listen to speech and other sounds  
from the outside world. Second, the peripheral holes **13** surrounding the central  
receptacle **8** form jets of air **82** which impinge on the microphone **10** when the user puffs  
through the simulated cigarette **17**. The jets of air **82** impinging directly on the  
30 microphone **10** create a relatively loud white noise which is recognizable as a puff by the  
sound recognition software.

An alternative embodiment also includes an LCD alphanumeric or graphics  
display **32** for communicating silently to the user. The LCD display might show a

5 pictorial representation of a cigarette as it is being smoked by the user, showing it getting shorter. Simultaneously, the LCD might show a deathclock, showing average life expectancy lost if present rate of smoking continues, counting up in realtime as the user smokes. And the LCD can display textual information to the user, educating them on other aspects of smoking.

10

The top 6 of the enclosure flips opens like a hardpack of cigarettes. Inside the top of the enclosure are pushbuttons for the user (student) 163 or supervisor (teacher) 179 to wake up the microprocessor. There is also an earphone jack 16 for communicating without disturbing those in the vicinity (such as in a classroom). The fliptop 6 also  
15 protects the buttons 163, 179 from being pressed inadvertently, and keeps the earphone jack 16 clean of dirt or pocket lint, since the device 1 is intended to be carried in a shirt pocket or purse.

The side 18 of the enclosure 1 has a recess 11 to hold a simulated cigarette or  
20 puffing device 17. The puffing device 17 is held externally so its storage area 11 can be easily cleaned with an alcohol swab for sanitary purposes.

Referring also to Figure 13, the puff device 17 with flow restriction 164 .  
The simulated cigarette or puffing device 17 has three main features: (a) A straw 165 that  
25 fits into the receptacle 8 on the enclosure 1, (b) A check valve 167 that prevents the user from blowing into the receptacle 8 and to keep the receptacle 8 clean for sanitary reasons, and (c) A fixed or removable filter 168 that acts as a flow restriction to simulate actual puffing resistance of typical cigarettes, as well as puffing difficulty caused by lung disease. A similar straw can also simulate inhaling cocaine and methamphetamines. An  
30 alternative embodiment for deterring other drugs replaces the simulated cigarette with a simulated hypodermic (without the needle) that emits an inaudible but recognizable whistle when "injected". The microphone 10 and software would hear and recognize the whistle and record that sound as an injection event.



Referring to Figure 4 some of the electronics of the present invention 1 can be appreciated. The simulator 1 is capable of both sensing sounds made by the user, such as coughing and inhaling, as well as generating spoken messages which instruct the user of the device. The speech recognition and speech synthesis functions are performed by integrated circuit 19, which is preferably an RSC-164 microcontroller and speech processing circuit manufactured by Sensory, Incorporated, 521 East Weddell Drive, Sunnyvale, California 94089. The specific function and features of circuit 19 are more fully described in United States Patent No.5,790,754, issued to Mozer et al. The circuit 19 is powered by three isolated power supplies and ground reference levels. Digital power source 90 supplies digital Input/Output pins 117, 118, 119 and 120. Filtering is accomplished by capacitor 121 and digital ground connection 122. Core power supply 87 supplies core processing via pins 33, 34, 123 and 124. Filtering is accomplished by capacitors 125 and 126, and core ground connections 127 and 128. Analog power supply 78 furnishes power for audio processing via pins 130 and 131. Filtering is accomplished by capacitor 132 and ground connection 133. Processing speed is controlled by a high speed oscillator network composed of crystal 134, capacitor 136 and capacitor 137, which is connected to oscillator pins 138 and 139. A low speed oscillator network consisting of crystal 140 and capacitors 141 and 142 is attached to microcontroller 19 pins 143 and 144.

The circuit 19 includes sixteen general purpose Input/Output ports 35-50. Each pin can be programmed as input with a weak pull up, an input with a strong pull up, an input without pull up or as an output. Microcontroller 19 also includes an external memory interface that allows connection to a standard nonvolatile static random access memory chip 20. Microcontroller 19 includes separate read and write signals for each external memory space. Microcontroller 19 is constructed with eight data input/output lines 21-27 and 30, which are interconnected to the corresponding data input/output lines 51-58 via data bus 59. Addressing is accomplished along address bus 60. In this particular use of the microcontroller 19, nineteen address lines (61-76 and 40-42) are used to address 512 kilobytes of memory stored in memory chip 20. The nineteen

5 address lines are connected to pins A0-A18 of memory chip 20. The microcontroller 19 controls memory access via pin 145 (read code), pin 146 (write code), pin 148 (read data) and pin 149 (write data). These pins are ANDED together by chip 150 to provide appropriate logic control to control memory chip 20, the latter being controlled by pin 151 (chip enable), pin 152 (output enable) and pin 153 (write enable). The data written to  
10 or received from memory chip 20 is transferred via the data bus 59 to connecting pins D0-D7 of microcontroller 19 and connecting pins 51-58 of the memory chip 20. Audio output is provided via speaker 9 which is attached to the pulse width modulation output pins 154 and 155 of the microcontroller 19.

15 Referring to Figure 10, the power supply 77 includes three separate power supply elements. The analog power supply 78 receives its input power from system battery supply 79 which is preferably formed from three "AAA" alkaline batteries wired in series. Capacitor 80 and diode 81 form a half wave rectifier or filter which also protects the remaining circuitry against incorrect (reverse polarity) battery insertion. Analog  
20 power supply 78 is isolated and filtered by resistor 83 and capacitor 84. The analog power supply 78 provides power to audio preamplifier 85 via terminal 86. The core power supply 87 is isolated and filtered by resistor 88 and capacitor 89. Core power supply 87 provides power to microprocessor 19. The digital Input/Output power supply 90 is isolated and filtered by resistor 91 and capacitor 92. The digital power supply 90  
25 provides power to memory chip 20. The resistor 93 and capacitor 94 form an RC network with a time constant of approximately 0.1 second, thereby permitting transients to decay prior to the application of power to RESET terminal 95. This ensures a clean reset and start of microcontroller 19 into an electrically stable environment. Diode 96 discharges capacitor 94 in the event of a major core power supply 87 transient, thereby  
30 providing for a reset of microcontroller 19 if such a transient occurs.

The audio preamplifier 85 is a four stage amplifier with a bandpass filter 97 and with a two bit automatic gain control circuit 98 as specified in the Sensory, Incorporated manual for the RSC-164 Development Kit. When terminals 99 and 100 are set for a high

5 impedance input, the maximum gain is approximately 59 decibels at the center frequency of 1.49 KiloHertz. This is a gain for a typical application with the microphone about 1.0 to 1.5 feet from the user in a quiet environment. This may vary depending on the ambient environment. The 3 decibel cutoff frequencies are 580 KiloHertz and 4.2 KiloHertz. Resistor **101** supplies the power to a standard two wire electret microphone **10**. The  
10 voltage divider resistors **102** and **103** are used to provide the DC bias for amplifier stages **104**, **97** and **105**, and it is set to approximately one third of the voltage appearing at terminal **86**. The first stage **104** has a gain of approximately 2.2. The bandpass filter **97** has a gain of approximately 7.8 at the center frequency of 1.49 KiloHertz. The two bit AGC circuit **98** is a programmable voltage divider consisting of Capacitor **106**, resistor  
15 **107**, resistor **108**, resistor **109**, resistor **110**, and capacitor **111**. In order to prevent DC level shifts in response to AGC changes, the AGC circuit **98** is AC coupled by capacitor **106** and capacitor **111**. The AGC input control signals appearing at terminals **99** and **100** may independently be either at ground or at high impedance, giving four different levels of attenuation. The gain ratios for the AGC circuit **98** are 1.0, 0.36, 0.18 and 0.13. The  
20 third stage amplifier **105** has a gain of 6.6, while the fourth stage amplifier **112** has a gain of 8. Resistors **113** and **114** provide adequate output bias current to prevent crossover distortion between third stage amplifier **105** and fourth stage amplifier **112**. Both of the output terminals **115** and **116** are AC coupled and then DC biased such that at full swing the negative peak voltage goes below zero volts DC (analog ground) at the the inputs of  
25 speech recognition microcontroller **19**.

There are several pushbuttons attached to the microcontroller **19** digital Input/Output ports **156**, **157**, **158** and **159**. For example, a momentary microswitch **160** is activated by pushing a dollar bill into a slot **254** in the box **2**. The switch **160** detects the  
30 action of a user paying for their cigarettes. A bellows switch **161** is an alternative method of detecting puffs or inhalations on a simulated cigarette. The bellows switch may also be replaced by a pressure sensor switch which can perform a similar purpose. Sound activated switch **162** , such as described in the Radio Shack catalog No. 276-5011A, is an alternative method of detecting either puffing on a simulated cigarette or coughing.

5 Similarly, the simulated cigarette can be designed to produce an audible or subaudible  
whistle tone during puffing. The whistle tone can be sensed by the sound activated  
switch **162** tuned with a bandpass filter encompassing the whistle tone frequency  
spectrum. The puff switch sensor can be eliminated by using a sound integrator or sound  
recognition software. In addition, the pushbutton **163** may be used to activate or wake up  
10 the microcontroller **19** when it is in a power saving mode.

The following narrative referring to Figure 5 assumes that the smoking simulator  
**1** is used in a school environment. The “Teacher” is the person who sets up the device **1**  
for use by the “Student”, and afterwards evaluates the student’s performance by  
15 commanding the device **1** to produce a recorded report. The various software flowcharts  
presented here are separated into modules which are functionally distinct from each other.  
The overview flowchart **169** shows the general relationship between modules, and the  
logical sequence of the flow of instructions from module to module. Subsequent  
flowcharts illustrate the inner workings within each module.

20 In many of the flowcharts there are references to Sensory, Inc’s proprietary  
software subroutines for various speech functions. Rather than explain them each time  
they are used, they are summarized here. Speaker Verification (SV) subroutines are used  
for storing and verifying passwords. SV subroutines can distinguish between individual  
25 speakers. Speaker Independent (SI) Recognition subroutines are used for recognizing  
specific commands or responses, no matter who says them. Speech Synthesis (SS)  
subroutines simply playback a prerecorded word, phrase, or lengthy message. Continuous  
Listening (CL) Recognition subroutines are used for recognizing specific commands or  
sounds that may occur at unpredictable times, and must be listened to for an extended  
30 period.

The software modules for the smoking simulation **1** are divided into two broad  
groups. The modules focusing on the teacher’s activities start with POWERUP step **170**.  
The student’s activities begin with the RUN module **171**. The teacher’s activities

5 configure the device 1 to recognize his or her passwords, provide the level of challenge they feel is appropriate and, after the simulation is completed, report the results of the student's use of the device 1. The student's activities include recording their passwords, responding to demands from the device 1 to cough or perform simulated smoking, and listening to extensive educational material. The student also has the option of bumming  
10 cigarettes from other students with similar devices 1. The active operating time of the device 1 is brief compared to the total time it is used, so it spends a large portion of time in SLEEP mode 174 to conserve battery power.

Referring also to Figure 6, when the battery 79 is connected, the microprocessor  
15 19 must perform a "bootup" procedure 172 to properly configure timers, input/output ports, and interrupts. Otherwise they might initialize in a random configuration. Once these basic housekeeping activities are done, the microprocessor runs the applications program for smoking deterrence. There is no on/off or "reboot" switch. Those functions are accomplished by connecting and disconnecting the battery 79. So each time the  
20 battery 79 is reconnected, the software must request and store in step 173 the passwords from the teacher. In the preferred embodiment password security is twofold: (a) the teacher can keep their passwords secret, and (b) the software recognizes in verification step 175 the voice patterns of the individual teacher, so it is difficult for a student to cheat even if they discover the teacher's passwords. The passwords are used to limit access to  
25 the subsequent simulation setup steps to the teacher alone. This precaution prevents the student from changing the conditions of the simulation.

A realtime clock, albeit not very accurate (say, plus or minus one hour), is needed to time some events for a specific part of the day. For example, as the exercise progresses  
30 to simulate more frequent smoking, the student may be awakened in the middle of the night to have a desperate smoke or have an extended coughing fit. Therefore the software asks for and stores the day and time of the start of the simulation in instruction set 176. The day is preferred because the software must report the total elapsed time of the simulation, and reporting the starting day and time is easier to understand than reporting

5 simply the number of hours elapsed. With the realtime clock initialized and running at  
clock startup step **177**, the device **1** can go to sleep and wait for the teacher to wake it up  
for further instructions to proceed with the student's portion of the software. Prior to  
entering sleep mode **174**, device **1** tells the teacher that it is awaiting their signal at  
prompt step **178**. This notification to the teacher is an attempt to make the device **1** user  
10 friendly and self-documenting.

Referring also to Figure 7, the teacher wakes up the device **1** by pushing at  
interrupt step **180** a wakeup button **179** which can be labelled "Teacher". Upon  
15 completing wakeup step **181**, the device **1** will verify that it is indeed the authorized  
teacher who is responsible for the activation by asking for and verifying the teacher's  
password at step **173**. If password verification fails, the software returns to the step **178**  
in the POWERUP module to notify the teacher that it is going to sleep to await a valid  
wakeup call. If the teacher's passwords are correctly verified, the software asks the  
20 teacher via request **182** to state one of several commands, such as Report **183**, Run **184**,  
Buy Cigarettes **185**, Packs Per Day **186**, Escalation Rate **187**, Metabolic Rate **188**,  
Susceptibility **189**, or Information Frequency **190**. If command recognition fails, the  
software returns to the step **178** in the POWERUP module to notify the teacher that it is  
going to sleep to await a valid wakeup call, just as it would if password verification  
25 failed. If the teacher commands Report **183**, the device **1** will recite the appropriate  
measurements of the student's activity with the device **1**. A few examples of data  
included in the report recitation are elapsed time, number of cigarettes demanded, number  
of cigarettes consumed, number of delays in responding to demands to smoke, and  
number of cigarettes borrowed. If the teacher commands Run **184**, the software will  
30 jump to the RUN module **171** where the student-related software begins.

The day-to-day monetary cost of smoking is one of its aspects simulated by the  
device **1**. The device **1** keeps track of an imaginary inventory of cigarettes, decrementing  
the inventory whenever the student smokes, and incrementing the inventory whenever the

student "purchases" more from the teacher. Therefore, when the teacher commands Buy Cigarettes **185**, the software will ask at step **191** for the teacher to set the number of packs of cigarettes available to the student before more must be purchased. The upper limit is high enough that it is effectively unlimited, in case the teacher does not want a limit. The software has several other variables which can be set by the teacher to tailor the simulation to their needs. The initial level of addiction can be set by commanding an initial smoking rate **192** in packs per day. The teacher also sets the escalation rate **193**, that is, how many days it takes to escalate from one pack per day to two or three or four packs per day. This will often depend on how long the student can keep the simulator before it must be used by someone else, and how rigorous a lesson the teacher wants the student to endure. For example, the medium settings simulates a one pack a day habit on the first day, two packs a day on the second day, and three packs a day on the third day. The student's physiological response to nicotine is simulated by setting two other variables, metabolic rate **194** and susceptibility **195**. These variables are described in the curriculum literature that accompanies the device **1**. In general, these variables are dependent on the student's level of physical activity (active or inactive) and body weight. The rate of educational information **196** recited to the student can also be set by the teacher. If the teacher sets the simulation to last only one day, the goal will typically be to inundate the student with a rapid rate of information **196**. If the simulation is intended to last a week, the information rate **196** may be reduced to a relatively meager rate. After each variable has been set by the teacher, the program returns via path **197** to ask the teacher to give another command. When the teacher finishes setting as many variables as they wish, the teacher will respond to the request for command with silence or a noncommand word. The software will then return to idling step **178** in the POWERUP module and notify the teacher that the device **1** is going to sleep.

Referring also to Figure 8, the RUN module 171 is an “Executive” routine because it performs calculations, checks lookup tables, and otherwise makes decisions that affect the course of events throughout the student’s use of the device 1. Most of the other modules in device 1 merely respond to calls from interrupts or from the RUN

5 module **171**. The RUN module **171** is the only module that makes activity scheduling decisions. Throughout the simulation, the device **1** will make demands of the student, await the student's response, and measure and record that response for eventual reporting to the teacher. Each time the student responds to a demand, the device **1** will verify that the response is coming from the correct student (the student to which device **1** was  
10 assigned). This keeps the students honest and prevents them from giving the device to, for example, a little brother, to play with. An added benefit is that when the student knows they cannot cheat, they pay closer attention.

To enable verification of the student's identity, the device **1** as a first step **198**  
15 records a student's password. The verification step **198** of the software can only be accessed immediately after the teacher executes Run command **184**, so the teacher will be present to ensure that the designated student records their voice-dependent password. Once this is done, the student cannot access verification step **198**. The passwords can only be changed by the teacher, using their own passwords, or by removing the battery  
20 **79**, which is detectable by the teacher since it will affect the realtime clock **177** as well as the teacher's passwords.

The student is given some choices to tailor the simulation to their personal preferences, which will hopefully give the student a greater interest in the results. First the  
25 student selects at step **199** a brand of cigarettes. Each brand will have its own market appeal, cost, nicotine content, and carcinogenic effect, which will be recorded in the device's memory **20**, and will be used in calculations that follow. The student next chooses a personality **200** for their device. The personality **200** traits apply to only a few of the messages from the device **1**, but are hopefully frequent enough to keep the student  
30 interested and paying attention. Personality **200** traits include Humorous, Sarcastic, Motherly, Scientific, Suggestive, Teenage or Random.

The core of the simulation scheduling software resides in the next two steps **201** and **202** which calculate the realistic physiologic effects on the student of the simulated



5 nicotine addiction defined by the values the teacher has previously set for the simulation variables. This includes calculation **201**, using equations from actual pharmacokinetic studies, of the student's simulated blood nicotine content using variables such as: (a) how long ago did they last smoke a cigarette, what brand of cigarette was it (nicotine contents vary), how fast did they smoke it, and how completely did they smoke it, (b) how fast do  
10 they metabolize nicotine, (c) what is their physiologic susceptibility to blood nicotine level, and (d) what time of day is it (metabolic rates vary).

From these physiological calculations **201**, the software will assign a simulated nicotine craving level **202** to the student. This craving level **202** ranges from mild  
15 agitation through many levels of anxiety and irritability all the way up to immobilizing nausea. This craving level **202** will be communicated to the student in several ways: (a) Demands for a smoke, (b) Nicotine level warnings, (c) General information and factoids, (d) Detailed descriptions of how they would feel and demands for how they should act, (e) Random and escalating nagging, and (f) General advice and guidance. Based on the  
20 student's simulated craving level **202**, the software will decide by using a series of lookup tables the appropriate level of intensity of educational messages at any given time during the simulation, and select the addresses within electronic memory **20** of the messages to playback to the student. In the extreme case where a student excessively delays smoking to the point of withdrawal, and the long delayed cigarette is finally smoked, the software  
25 could demand a vomiting episode in which the student must make a retching noise that the software can recognize. That particular activity is scheduled in the nicotine craving level step **202**, although it is actually performed in the SMOKING ACTION module **203**.

As the simulation progresses to higher levels of addiction and more frequent  
30 smoking, the calculated physiologic effects **201** will escalate, and the simulated damage to the student's lungs will accumulate. Part of this calculation is based on the carcinogenic effect of the cigarette brand chosen by the student. As a result, the device **1** will demand more frequent and more severe coughing fits from the student, eventually to

5 the point of waking the student up in the middle of the night to cough, smoke, and cough some more.

Other information that may be calculated and communicated to the student includes pulse rate variations, lung capacity reduction, blood pressure increase, stress on  
10 the heart, and other diseases or conditions to which smokers may be susceptible because of their smoking. The software will update the value of a “Deathclock” that measures the expected minutes/days/years of lifespan lost assuming that the current trend of simulated smoking proceeds unchecked. The deathclock is calculated by nicotine craving level block **202** but reported in the SMOKING ACTION module **203**, immediately after the  
15 student smokes, to give the student immediate feedback on the long term consequences of their smoking.

Once the nicotine craving block **202** has calculated what messages regarding smoking, coughing, and educational information should be communicated to the student,  
20 and when they should be communicated, the software will setup internal timers **204** to wake itself up at the appropriate times. The device **1** will go to sleep and wait for those interrupts. Once asleep device **1** will also respond to pushbutton interrupts from either the student or the teacher.

25 Referring also to Figure 9, the smoking notification module **205**, which is called by the RUN module **171**, simply notifies the student that it is time to smoke. The student must respond via the Student Pushbutton **163** before simulating smoking. Simulated smoking is processed by the SMOKING ACTION module **203**. The device **1** has three notification methods **206** of notifying the student that it is time to smoke. There is a  
30 pager-type vibrator that the student can feel if the device is in their pocket. There is a beeper-type beep that the student can hear if the device is in their purse or if they are asleep. Finally, after a short pause, there is a spoken demand for smoking. After notifying the student, the device scheduler **207** sets the next notification for five minutes in the future. This ensures an irritating nagging process for as long as the student puts off

5 smoking. Then the software returns to calculator **201** and nicotine craving block **202** in the RUN module **171** to recalculate the student's simulated nicotine level and craving level based on the extra time elapsed, and then returns to sleep mode **174**.

As seen in Figure 11, the Information Notification module **208**, which is called by  
10 the RUN module **171**, simply notifies the student that it is time to listen to educational information. The student must respond via the Student Pushbutton **163** before listening to the information. The device **1** has three methods **209** of notifying the student that it is time to listen to information. There is a pager-type vibrator that the student can feel if the device is in their pocket. There is a beeper-type beep that the student can hear if the  
15 device is in their purse. And finally, after a short pause, there is a spoken demand for the student to listen to information. After notifying the student, the device **1** sets the notification timer **210** for five minutes in the future. This ensures an irritating nagging process for as long as the student puts off listening to the information. Then the software returns to the calculator **201** in the RUN module **171** to recalculate the student's  
20 simulated nicotine level, craving level and message intensity level based on the extra time elapsed. The device **1** then enters sleep mode **174**.

As seen in Figure 14, the COUGHING INTERRUPT module **211**, called by the RUN module **171**, both notifies the student that it is time to cough, and monitors whether they  
25 do or do not cough. This action cannot be delayed, only passed or failed. The Student Pushbutton **163** is neither required nor active when module **211** is active. The device **1** has three methods **212** of notifying the student that it is time to cough. There is a pager-type vibrator that the student can feel if the device is in their pocket. There is a beeper-type beep that the student can hear if the device is in their purse. And  
30 finally, after a short pause, there is either a spoken demand for coughing or loud playback of a recorded cough. In order to wake up students in the middle of the night, the device **1** may playback a coughing fit rather than a spoken demand. After notifying the student, the device **1** initiates verification step **198** by asking for the student's passwords, thereby making sure that the right student will be coughing.

The RUN Executive routine **171** will pass a parameter to coughing module **211** specifying the demanded intensity of the coughing episode. The parameter may specify anything from a single hack to an extended coughing fit. The coughing module **211** will at cough prompt **213** ask for, listen for, and recognize the student coughing some specified number of times. If the student fails to cough appropriately, the device will give them the option **214** to try again. Their success **215** or failure **216** will be noted before returning to the RUN module **171** for recalculations **201** and the return to sleep mode **174**.

After the student has been notified that the device demands either smoking or information playback, the student can press the Student pushbutton **163** to indicate that they are ready to perform the demanded action. This wakes the device **1** up from the sleep mode **174**. After awakening, the device **1** asks for and verifies at step **198** the student's passwords to make sure that the correct student has awakened the device **1**. Next, the device **1** asks for the student's command **217** to either smoke, bum cigarettes, or playback educational information. At this point, depending on student delays, random chance generator **218**, and recognition by the software of extraneous epithets, the software may select belligerence path **219**. For example, the software may randomly tell the student that they are out of matches. If the software follows belligerence path **219**, repetition step **220** will tell the student to try again later, or issue a similarly appropriate message. If the software cooperates with the student via cooperation path **221**, as it most likely will, then the program returns to either the smoking action module **203**, bumming module **222**, or information playback module **223**.

Referring also to Figure 16, the smoking procedure **203** begins with an internal check **224** to see if there are any simulated cigarettes remaining in inventory. If not, the device **1** will so inform the student via announcement **225** and then return to the RUN module **171** for recalculations **201** and sleep **174**. From the RUN module **171** the student

5 can either wake the device and bum a cigarette from another student via module **222**, or “buy” cigarettes from the teacher. If there are cigarettes remaining, the device will execute announcement **226** and tell the student to “Puff away”, then enter a Continuous Listening subroutine **227** to listen for puffs at variable intervals.

10 When each puff is recognized, the consumption rate step **228** will calculate how much of the cigarette has been smoked. This calculation **228** will include the intensity and duration of the puff as well as the interval since the last puff. If the cigarette is not done, the program will follow return path **229** to subroutine **227** and listen for another puff. If this was the first puff occurring after nicotine withdrawal as calculated by counter  
15 **230**, the program will execute demand **231** for a retching sound from the student. After the retch is recognized the device **1** will tell the student, via message bank **232** a message chosen by random message generator **233** such as “You just barfed on your lit cigarette. You must smoke another, after washing your hands.” or “Barf into a toilet, then flush the toilet”. The device **1** will listen for and recognize via sound monitor **234** the sound of the  
20 toilet flushing. If no puff is heard at step **227**, the software will continue to ask the student if they wish to try again **235**. If not, the software will record a failure **236** and return to the RUN module parameter calculator **201**.

When the cigarette is done there may be another randomly generated smoking  
25 event **233** such as the device **1** saying, for example, “You burned your fingers! Scream out loud!” or “You burned a nearby piece of furniture. Put a stickon burn decal on a nearby piece of furniture”. After a pause, the device **1** enables deathclock monitor **237** and says “Done” and reads out the value of the Deathclock. The software records the accumulated duration and intensity of puffs from this cigarette at recorder **238** for use by  
30 the RUN module in recalculating blood nicotine level at calculator **201**. Then the cigarette inventory **239** is decremented, and the software returns to the RUN module for recalculation **201** and sleep **174**.

5           Students must perceive this overall simulation device **1** as realistic in order to embrace and make the most of the educational experience. Borrowing or “bumming” cigarettes is a realistic feature of the device **1** intended to encourage active communication among students. As best understood by reference to Figure **17**, if two students with similar devices **1** agree that one will allow the other to bum a cigarette from him, then the two of them will simultaneously wakeup their devices **1** and command them to enable the bum cigarettes module **222**.

Each device **1** will ask its student whether they choose to give or receive a cigarette at question **240**. The donating device **1** will check its inventory to ensure that it has cigarettes to give. If there are none, device **1** will inform the student along failure path **241** and return to RUN module step **201** and sleep mode **174**. If the device **1** does have cigarettes to give, device **1** will listen **242** for a unique “Receiving” tone from the other device **1** asking for a cigarette. When the software recognizes **243** the “Receiving” tone device **1** will immediately playback **244** a unique “Given” tone (actually a secret composite tone so it is difficult to counterfeit) for a few seconds. Then the software will decrement **245** its inventory of cigarettes and return to the RUN module **201** and sleep mode **174**.

The “Receiving” device **1** will begin a loop **246**, lasting a maximum of ten seconds, during which loop **246** will alternately playback the “Receiving” tone for half a second, then listen for half a second for the “Given” tone of acknowledgement from the other device **1**. Once device **1** recognizes **247** the “Given” tone, the software increments **248** its inventory and returns to the RUN module **201** and sleep **174**.

30           The total number of cigarettes given and received is recorded and reported to the teacher so that cheating (e.g. bumming one cigarette to multiple receivers simultaneously, or tape recording the “Given” tone) can be easily detected. One can eliminate cheating by embedding a unique two-way code in the transmitted tones, or by requiring one-to-one physical connection between devices for communications. Typically, the device’s added

5 complexity and cost are not warranted since occasional counting by the teacher will suffice to deter cheating.

There are many methods of communicating between devices for bumming cigarettes. As a passive example, one might install contacts on each box connected to a  
10 100K ohm resistor. When the devices are touched together in parallel, the resistance drops to 50K ohm. The microcontroller **19** can measure this resistance reduction. As an active example, the students might touch together contacts on the devices while pushing appropriate buttons. The preferred approach adds no hardware or software beyond that which already exists for tone playback and recognition.

15

As best seen in Figure 18, every piece of educational information that is recited by the device **1** ends with a true/false or yes/no question **249**. Listening interval **250** begins thereafter to determine if the student has answered the question **249**. The student must give the correct answer **251** to the question **249** in order to prevent the information from  
20 being repeated at some later time. The software records whether the question was answered correctly at register **252** or incorrectly at register **253** before returning to the RUN module for recalculation **201** and sleep mode **174**.

As those skilled in the art will appreciate, the simulator **1** can be equipped with a  
25 variety of different programs with different timings, information, and curriculum depending on whether the device **1** is simulating, for example, smoking tobacco, marijuana, ingesting cocaine, or injecting other drugs.

30